Reflective Imaging Encoder

BACKGROUND OF THE INVENTION

Field of the Invention

The present invention pertains to the art of optical encoders, and more particularly, to the art of reflective optical encoders.

Art Background

Optical encoders are used in a variety of applications such as shaft encoders where an object's position or motion is sensed. In a reflective encoder, light from an emitter, usually a light emitting diode is directed at a coder such as a code wheel in the case of sensing rotary motion, or a code strip in the case of sensing linear motion. Specular reflections from reflective areas of the coder selectively reflect light from the emitter to a detector.

The performance of such an encoder and its resolution are limited by, among other considerations, the low degree of collimation of the emitter beam, diffused and scattered light caused by coder imperfections, and distortions due to encapsulation surrounding the detector.

SUMMARY OF THE INVENTION

A reflective imaging encoder comprises an emitter which may be one or more light emitting diodes, a diffuse reflective coder such as a code wheel or code strip reflecting a portion of the light from the emitter, and an imaging lens forming an inverted image on to a detector. The emitter and detector may be coplanar or mounted on the same substrate. Apertures on either side of the imaging lens may be included, and baffles may be used to minimize stray light reaching the detector. The imaging lens may be separate from the detector, or incorporated into the encapsulation of the detector.

BRIEF DESCRIPTION OF THE DRAWINGS

The present invention is described with respect to particular exemplary embodiments thereof and reference is made to the drawings in which:

Fig. 1 shows a reflective encoder according to the prior art,

Fig. 2 shows a reflective imaging encoder according to the present invention,

Figs. 3a 3b, and 3c show emitter embodiments for use in the present invention,

Figs. 4a and 4b show embodiments of emitter configurations for use in the present invention,

Figs. 5a and 5b show embodiments of apertures and detector configurations for use in the present invention, and

Fig. 6 shows a second embodiment of the present invention of a reflective imaging encoder.

DETAILED DESCRIPTION

Fig. 1 shows a reflective encoder according to the prior art. Emitter **100** produces light rays **110** which strike coder **120**. Reflected light **130** hits detector **140**. Emitter **100** and detector **140** are mounted on substrate **150**, and may be encapsulated **160**. As coder **120** moves, changes in reflected light **130** change, and are sensed by detector **140**. As is known to the art, emitter **100** is commonly a light emitting diode (LED). The operating wavelength of emitter **100** is commonly application specific, depending on considerations such as the nature of coder **120** and detector **140**. Coder **120** preferably is of diffuse nature and able to selectively reflect emitted light rays **110** producing reflected light **130**. Coder **120** is commonly a code wheel, used for sensing rotary motion, or a code strip, used in sensing linear motion. Coder **120**

comprises alternating reflective and nonreflective elements. Detector **140** is commonly an array of photodiodes or similar CMOS imaging sensor.

Fig. 2 shows an embodiment of a reflective imaging encoder according to the present invention. Emitter **101** produces light rays **110** which strike coder **120**. Reflected light **130** from coder **120** then passes through imaging lens **135** and is imaged on to detector **140**. As shown in Fig. 2, imaging lens **135** reverses reflected light **130** from coder **120** to detector **140**. As coder **120** moves from right to left in Fig. 2, the pattern of reflected light **130** striking detector **140** moves left to right. Emitter 101 is preferentially one or more light emitting diodes (LEDs), in the form of bare LED dice or encapsulated devices in order to improve light intensity against loss due to diffuse reflection of coder.

Figs. 3a and 3b shows emitter embodiments for use with the present invention. As shown in Figs. 1 and 2, coder **120** is commonly mounted midway on the optical path between emitter **101** and detector **140**. In such an arrangement it would be beneficial for emitter 101 to produce most of its illumination at an angle. Fig. 3a shows one embodiment of an encapsulated emitter **102,** which achieves this result. Commonly, the light emitting diode die in an encapsulated LED is mounted on the package's optical axis to focus light emitted from the die normal to the LED package. As shown in Fig. 3a, light emitting diode die **100** is mounted offset from the optical axis of encapsulation **160**. This produces light rays **110** at an angle off normal. Fig. 3b shows an additional embodiment **103** in which light emitting diode die **100** is mounted in a reflector cup **155** which reflects incident light emitted from the edges of die **100** upward to maximize flux extraction. Again, emitted light rays **110** are produced at an angle off normal. Fig. 3c shows another additional embodiment **104** in which a packaged LED **165** is mounted on the substrate **150** as a separate component using different assembly process as compared to the emitter embodiments **102** and **103**. The emitted light rays **110** from the packaged LED **165** are produced, preferably, at an angle off normal.

Figs. 4a and 4b show alternate embodiments for producing off-axis illumination form an emitter. In Fig. 4a, light rays **105** from emitter **101** are altered by optical element **115,** which may be a wedge or lens. In Fig. 4b, light rays **105** from

emitter **101** are altered by reflective element **115**. This reflective element may be a flat mirror, or may be curved, such as a parabolic or hyperbolic mirror.

Figs 5a and 5b show apertures used to reduce stray light reaching detector **140**. In Fig. 5a, apertures **138** restrict light entering or leaving imaging lens **135**. Apertures may be present between coder **120** and imaging lens **135**, or between imaging lens **135** and detector **140**, or both. Also shown in Fig. 5a is the image inversion caused by imaging lens **135**. Point P **122** on coder **120** is imaged by imaging lens **135** to point P' **142** on detector **140**. Point Q **124** on coder **120** is imaged by imaging lens **135** to point Q' **144** on detector **140**. Fig. 5b shows a single aperture **138,** and an imaging lens **133** integrated as part of the encapsulation covering detector **140**.

Fig. 6 shows a second embodiment of the present invention. In this embodiment, multiple emitters **101** mounted to substrate **150** are used. In addition to aperture **138**, baffles **170** are provided to shield detector **140**. Baffles **170** need not meet aperture **138**. Baffles **170** may surround detector **140**, or may only be needed to interrupt direct paths between emitters **100** and detector **140**.

The foregoing detailed description of the present invention is provided for the purpose of illustration and is not intended to be exhaustive or to limit the invention to the precise embodiments disclosed. Accordingly the scope of the present invention is defined by the appended claims.